HOW CAN SUSTAINABLE DESIGN INSURE RESILIENCY THROUGH THE

BIODIVERSITY OF A BOOMTOWN

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Jesse M Riley

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SUPERVISORY COMMITTEE:

Dr. Jack Norland
Chair

Dr. Christina Weber

Matthew Kirkwood

Approved:

5/8/2015	Shawn DeKeyser
Date	Department Chair

ABSTRACT

Presently the state of North Dakota is enjoying tremendous economic expansion as well as an increase in population. The development of the Bakken Oil formation has introduced a new set of opportunities and presented a new set of challenges. By studying past boomtowns, ecology, and design, a path for planning, recruitment and maintaining communities with a sustainable approach can be explored. The purpose of this research is to guide current and future stakeholders in the area of energy development communities and wise growth planning. The many articles and books that are devoted to social science, ecology, design and population recruitment will aid in presenting a case for realizing a sustainable future for the state of North Dakota and the use of its natural resources.

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CONTEXT

This research will synthesize existing research to aid in sustaining the state's economic, cultural and environmental systems. Currently the state is experiencing an economic expansion but the future is uncertain. A substantial reason for an increase in population and economic development is a result of oil exploration. When natural resources increase in demand, and large projects requiring large capital investments in infrastructure and facilities are needed, a town will boom and systems will change. It is for this reason we will use the term "Resource Boomtown" when referencing the boomtowns generated by natural resource development or extraction. High volatility in energy prices, low housing availability, high crime rates, and environmental degradation are all seen as head winds towards continued sustainable development. Now that the boom is in full swing it would be beneficial to reassess and establish well thought out strategies to ensure continued future vitality.

SOCIAL

The social problems associated with rapid expansion have begun to emerge. The development of the state's natural resources has brought in thousands of migrant workers putting stress on existing services and infrastructure. If left unchecked these issues facing western boomtowns might only get worse. Through research in design and examples from the biological world, solutions may be developed in areas such as urban overcrowding, environmental degradation, social stakeholder development and recruitment, as well as park system infrastructure. The synthesis of these topics can be used to help resource boomtowns—defined in this document as great increases in the level of migrant workers moving to an area to develop resources such as oil, gas, copper, coal etc.--sustain their cultural, economic and natural systems during stressor events and shocks to the systems.

Who is developing Natural Resources in North Dakota?

North Dakota's main natural resources are agriculture and energy. The main ecological landscape feature is grassland prairie. The prairie is the reason for the abundance of fertile soils of the area. Even animal habitats benefit from these resources. The state's wetlands and grasslands are key components in the migratory corridor for several bird species. Besides agriculture the region is blessed with many abundant natural energy resources – coal, oil, gas, wind, solar, biomass, ethanol, power generation, and others. From time to time out of state interests descend on this state in an effort to extract its mineral resources for financial gain. Unlike the energy sector, the vast majority of agricultural stakeholders have ties and social equity in local communities. By right the citizens in resource abundant areas should have a voice in how their natural resources are removed, used and altered.   Involvement at this stage may be difficult because time and information is limited. The growth and development of Resource

Boomtowns have the potential to cause degradation and draw down an area's most precious natural assets.

Boomtowns

A number of research initiatives examining the impacts of oil and gas projects in the western United States in the 1970's and 1980's have articulated common economic and social consequences for small communities. This led to the development of the 'Boomtown Impact Models' [1] [2]. By the late 1970's, a so-called "boomtown model" or "social disruption model" emerged as a prominent framework among researchers to describe the rapid growth that overwhelms local governments and permanently alters social relationships. The body of evidence tended to find a mix of positive and negative economic impacts to local residents, contrasted with highly negative social impacts [3] [4] [5] [6] [7]. Some of the concerns brought about with the recent surge in development and population are as follows: crime and anti-social behavior, economic inequality and marginalization, straining of core services, marginalization and isolation of women pioneers, shifting social networks, environmental issues and economic instability.

Negative impacts of Resource Boomtown

Once the initial enthusiasm stage of boomtown development gives way to uncertainty, the impacts, both the positive and negative, begin. The most dramatic changes occur during construction or exploration phase. A study of the town Craig, Colorado reported dramatic increases in drug and alcohol abuse, family disturbances, child behavior problems, and crimes against persons. This rate of increase substantially exceeded the growth rate of the community, and data suggests that problems were nearly evenly divided among old-timers and newcomers [8].

Negative impacts to social systems are obvious during the onset of development. What is harder to discern are the natural, cultural and economic systems impacts taking place.

Natural impacts

The citizens of boomtowns often express concerns about the land and how oil exploration can have negative impacts on the environment. Many concerns arise before and during the exploration phase. This is when the seismic testing, well drilling, truck driving, and man camp construction takes place. Taylor and Winter [9] assert "The main environmental concerns include; permanent change to bio-systems, increased carbon emissions, general pollution and waste disposal issues, re-vegetation and clean-up costs". "People obtain drinking water from either surface water, which includes rivers and reservoirs, or groundwater aquifers, accessed by public or private wells. There are already a host of documented instances in which nearby groundwater has been contaminated by fracking activities, requiring residents with private wells to obtain outside sources of water for drinking and everyday use" [10] [11]. These concerns are often seen as anti-business or anti-growth. While these concerns are valid, all too often they do not resonate with non-residents of boomtown and development areas.

Social impacts

Not many rural areas are equipped to deal with the social impacts that come from such a pulse like the one brought on by the Bakken oil shale development. Towns can typically deal with annual population growth rates of 5%, but rates in excess of 15% lead to institutional breakdowns [1]. Kohrs[12] lowers this population increase even further and states the number as low as 6% annual growth the point which conditions start to expand beyond control. After decades-long population drain, North Dakota became the fastest growing state in the nation in recent years, expanding by nearly 10 percent in a 50-month period ending last June of 2013,

according to Census figures. That pace dropped sharply in 2014, but the state still preserved its

No. 1 growth ranking [13]. While the growth is touted as a victory for the state and the nation as a

whole, many are left to adjust to the change in the social structure and networks they once knew.

Women

Large oil and gas projects are hallmarked by the arrival of disproportionate numbers of

males for the construction phase [14]. Chang[15] asserts that male arrivers fail to adjust well to their

new environment, creating loneliness and a situation where alcoholism, drug abuse and violence

are pervasive, leading to crime and general social deterioration. Some of the first negative

impacts start to materialize as early as the construction phase. The social systems are negatively

affected by the influx of male outsiders whom are maladjusted to living in isolated areas. In an

attempt to balance the social dynamics of the situation, the logical solution seems to be to invite

more females to the area; unfortunately, it is not that easy. Jobs for women exist in the oil patch.

In order to insure the social vitality of any isolated boomtown it is paramount that the problem of

male biased population be addressed.

While not as bad as previous decades, the exploration phase is still for the most part male

dominated. The majority of resource related boomtowns present reduced opportunities for

partnering and long term family formation. Even if a well-intentioned pioneer set out to make a

better life for their family in the new community, the task may prove difficult.   For example, a

woman accompanying her employed husband to a boom community may be able to survive

isolation for several months on the strength of the marriage relationship alone. However, if she is

unable to eventually develop other support within the community she may become depressed,

divorced, or may force her husband to leave his job and the community in order to save the

marriage [16]. Targeting women for employment in the resource rich communities would be

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beneficial. The need for resources and a community to unify in the commitment to deem this problem as a worthy issue is pivotal.

Economic impacts

Once a boomtown begins to progress, bust strategies are rarely considered. The positive outlook and perceived endless demand brought upon by scarcity in the labor, real estate, materials and services markets clouds judgment for wise economic planning. The projected economic growth rarely matches the expectations of local businesses because these tend to be unrealistically high, having been established from the espousal of the project by the industry or government [9]. Boomtowns and oil production tax local resources and burden current infrastructure. Without proper planning what was once seen as a positive economic windfall, can begin to drain economic resources from state and local governments.

Lessons to be learned

The contraction of an expanding development trajectory provides a time for reflection and reassessment. If government officials and economic stakeholders have not established good growth management strategies, then a bust can elucidate these entities as to the importance of doing so. Merrifield [5] contends that without the funds to make the needed investments, the projection of impacts and planning of mitigation measures is but an interesting exercise. If these bodies are fortunate enough to just be experiencing a pause or slump in economic expansion, then the communities, economies and natural resources stand a chance to be maintained and improved.

Mitigation

By diversifying the economy during the exploration/construction phase a community can insulate itself from over specific sector imbalance. The concerns that arise during boomtown

expansion which can turn into bust cycle lessons should be attempted to be mitigated. A series of strategies for long and short term goals should be adopted [2]. Communities should define the historical patterns of service demand and identify capacities for growth, and then prepare mitigation strategies for when these thresholds are crossed. Perhaps most importantly, communities should prepare for the volatile nature of energy development and design strategies that are both short term mitigations and long term investments in their communities.

Short term procedure for any drastic economic expansion should be to establish a committee to plan and monitor growth. The next step would be to monitor and asses growth as its happening. During the ramping up phase of resource and energy development, problems begin to emerge. During this phase it is also important to re-evaluate the pre-construction projections. With plans coming to fruition and stressor limits being reached, it may be time to launch mitigation strategies. If mitigation strategies appear to be successful then the long term growth plans could be established and enacted. If planning is successful long term residents will be needed to continue social and economic development.

How do we find more people to become social stake holders?

Western North Dakota has gone through a series of boom and bust cycles. The oil has been there for millions of years and new technology has allowed for the cost of oil extraction to once again be economically viable. If the industry leaders and government officials desire to maintain a productive workforce for the production phase of oil development, than plans should be enacted to encourage new comers to stay on and become permanent residents. The state cannot home grow enough workers to maintain such a large production demand. A study by Fahys-Smith [17] on those who do become residents suggests the main factors influencing this are; time in the community, the tenure and security of the job, their age, housing opportunities

and their satisfaction with facilities and services. However, as the case with many boom towns, most migrants arrived with the hope of making quick money, without having the intention of settling permanently in town and many of them did indeed leave the town after a short period of time [18]. Certainly, this 'footloose' attitude of the migrants showed little interest in building decent houses and neighborhoods, as they considered the town merely as a temporary workplace rather than a permanent home [19]. If new comers do not have a stake in the community, they will be less concerned about its demise.

Plan on adequate social assimilation

Changes related to population growth need not produce such disruptive results. Cooperation among industry, government and local residents can implement measures that encourage people to help contribute to a well-balanced and healthy culture. "Well planned and coordinated human services and programs designed to relive the stresses of change, to provide a sense of community, and to integrate newcomers into the community can reduce or prevent many of the negative impacts as well as reduce overall costs of building on existing resources" [20]. The old timers are leery of the newcomers, and are less likely to engage by not allowing new comers to join their social units. A town needs to rapidly develop a positive sense of community integration programs that are designed to support the systems of assimilation.

How do we sustain?

There will be a day is which the resources that have drawn so many people to the Bakken have been depleted or degraded. What will be left in the wake of mineral exploitation? Proper planning and investments need to be made now to avoid documented bust cycles. Special consideration needs should be considered for the social and physical safety of women to a new area of development. By diversifying the economy during exploration/construction phase a

community can insulate themselves from over specific sector imbalance. The health of the natural systems is as important as the social and economic ones.

When analyzing the social factors of North Dakota oil exploration, its important study past examples of resource boomtowns. The evidence from this research paints a dire outlook for the social systems involved in the rapid expansion. In an attempt to mitigate the negative boom and bust impacts, examples from the natural world's ability to handle stressors could be used. These teachings could aid in designing a system to recruit and retain lasting groups of vested stakeholders.

BIOLOGICAL

How do we use our resources?

Humans for centuries have had their lives shaped by local natural resources. Varying resources are found in different geographical areas throughout the world but the demands for these resources fluctuate. The desire for these resources is forever changing. We as inhabitants of this world are affected by these resources, and the effects bringing them to market have on our culture and our land. The interactions of humans with the urban environment have been primarily the province of planners and landscape architects. For example Central Park in New York City and other urban parks designed by Fredrick Law Olmstead seem intuitively to link environmental properties to human wellbeing in cities. In particular, Olmstead's design for the Boston Fens and River way shows ecological prescience in its sophisticated combination of wastewater management and recreation amenity [21]. Ian Mcharg's [22] Design With Nature alerted planners and architects the value of incorporating knowledge of ecological and natural features among the usual engineering, economic, and social criteria when developing a regional plan. In McHarg's approach, environmental risks and amenities of different types are mapped in separate layers. The composite map suggests where certain types of development should or should not go [23]. Now that more research has been conducted and the benefits of environmental planning have been accepted, it is important to use lessons learned to enhance our built environments. The state of North Dakota has been fortunate enough to be situated atop a vast deposit of shale oil. This has led to economic development and worldwide attention. This in turn provides the state and its stakeholders with a tremendous opportunity to showcase to the world how to develop resources in a way that is responsible to the planet and to the local areas of extraction.

Ecological Footprint

How do our uses, activities, and choices affect the world as a whole? A useful way to quantify the dependence of urban systems on ecosystems beyond their borders is the concept of the ecological footprint. The ecological footprint of an urban area indexes the amount of land required to produce the material and energetic resources required by, and to process the wastes generated by a metropolis [24]. In this day, of this age, the world is connected through communication networks and resources that are extracted several miles from their uses. When humanity is considered a part of nature, cities themselves can be regarded as a global network of ecosystems. If compared with true natural ecosystems, the man-made ones are considered immature due to features like rapid growth and inefficient use of resources such as energy and water [25]. Developing land and harvesting resources can be profitable but can also transform the cultural and natural needs of a region. Before eliminating parts of an ecosystem it is important to understand what will be lost.

Ecosystem services

The cost of infrastructure and sustainable amenities can often worry planners, developers and government officials. Designs that encourage sustainable uses can often time yield financial benefits for the local municipalities and the regions who utilize them. These benefits are known as ecosystem services. They can be direct or indirect. They are "the set of ecosystem functions that are useful to humans" [26]. Although people have been long aware that natural ecosystems help support human societies, the explicit recognition of "ecosystem services" is relatively recent [27] [28].

The Millennium Ecosystem Assessment published in 2005, [29] divided ecosystem services into four categories:

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Provisioning services- or the supply of goods of direct benefit to people, and often with a clear monetary value, such as timber from forests, medicinal plants, and fish from the oceans, rivers and lakes. This service regionally includes the agriculture, forestry and energy production. This service provides many members of society their food security, medicine, and livelihoods.

Regulating services- the range of functions carried out by ecosystems which are often of great value but generally not given a monetary value in conventional markets. They include regulation of climate through the storing of carbon and control of local rainfall, the removal of pollutants by filtering the air and water, and protection from disasters such as landslides and coastal storms. Examples of these services regionally include water purification through wetlands and protection from natural disasters such as flooding and erosion.

Cultural services- not providing direct material benefits, but contributing to wider needs and desires of society, and therefore to people's willingness to pay for conservation. They include the spiritual value attached to particular ecosystems such as sacred groves, and the aesthetic beauty of landscapes or coastal formations that attract tourists. Examples of these services could be used for recruitment and retention of workforce labor. Statewide the industry of tourism greatly benefits from this service. The indirect service of identifying with nature and its connections are priceless.

Supporting services-not of direct benefit to people but essential to the functioning of ecosystems and therefore indirectly responsible for all other services. Examples locally include the formation of soils and the processes of plant growth. These services are necessary for all other ecosystem services and processes.

Many functions in the natural world also benefit humans. It is for this reason that stakeholders should weigh these benefits seriously when large scale development is considered.

In fact these ecological assets should be realized as strength to development instead as an obstacle.

How do we leverage?

An ecosystem can be defined as "a set of interacting species and their local, non-biological environment functioning together to sustain life" [30]. Ecosystems benefit the natural world but scientists are starting to quantify these services for us. It may be that one facet of the environment is being degraded as another is being developed. It is for this reason that a system wide approach should be considered when marketing the goods and services from any individual sector. If energy resources are in high demand then civic leaders are in a strong position to ensure future social, environmental, and economic stability.

How do we protect?

The recent boom in oil exploration and modern efficiencies in agricultural sciences have been perceived by many as a positive occurrence for the state of North Dakota. The increase in population and tax revenue has been touted as progress. But progress for who? The social makeup of the state may be changing and at such a fast rate that its citizens may not recognize the end product. In a democratic society made up of responsible stakeholders, members should have governance over the cultural, economic, and ecological systems they occupy.

Proper planning during initial stages of exploration can begin to mitigate the harmful effects of rapid unplanned growth. Protection of economic vitality leading to resiliency can be achieved by planning the recruitment of productive stakeholders and creating greater diversity in the employment sectors. Becoming resilient is achieved by allowing members of the community a chance to socialize in diverse natural settings and work in several sectors which are dependent on different economic factors.

Foresight ecology

In nature certain indicators can often foretell impending threats and outcomes. These indicators can be studied and developed into tools. One tool such as horizon scanning is   a method for collecting data from many existing sources and using that data to forecast progressing issues and understanding them better [31].   Scenarios' planning is also a tool where planners discuss many outcomes rather than just one prediction to a perceived outcome. By using these and other foresight ecology methods to predict the future negative stressors to a system, mitigation and deterrent strategies can be integrated.

Planning

One way to insure the people have a voice is for them to be provided more information about the resources they share. Informed citizens lead to informed choices. Local decisions could be made by local residents (the ones who will have to live with the consequences).Decentralized approaches to policy and planning, including community-based resource management, are often said to be a more democratic means of managing natural resources [32] [33] . According to this view, localizing planning and management overcomes the anti-democratic or insensitive character of the centralized bureaucracy that typically has a pivotal role in resource governance [34]. Greater local planning would give new recruits an opportunity to have a say in the local governance thus feeling like a part of society.

Civic groups could form to articulate a voice concerning the development of their towns. The stages of group developments could be as follows:

1. Initial mobilization and group formation: In this initial stage with key issues of membership, leadership, familiarization, and the development of group protocols financial and other resources occur.

2. Early developmental learning and implementation: In this stage, the group begins to act, and the crucial work of capacity building of members and client groups, mostly through learning by doing occurs before the gradual emergence of tactical planning and strategic action.

3. Functional maturity: In this next stage the group clarifies its purpose and possible feasible means of achieving them, conducts some experimental activities, and begins to understand their resource and financial requirements.

4. Persistence: In the final stage, the organization seeks to sustain its efficacy so as to maintain the interests of its participants, obtain sufficient financial and other support to operate and to be adaptable to changing circumstances [35] [36] [37].

With proper planning residents and public officials can have more say on the development of their communities and the diverse elements of their composition. Proper planning and mitigation of the negative effects brought about from resource boomtowns can have greater success if areas strive for diversity in the areas of culture, economy, and environment.

Bio-diversity

The lesson bio-diversity teaches us in nature holds value across economies and cultural networks. "An area with a variety of biotopes will have a large number of ecological species that can be occupied by many different species, and will thus increase biodiversity"[38]. The importance of diversity in nature is the ability of a separate organism to continue to do the work of one that is no longer able to. Whether it is due to stress or disturbance, something is there to complete the function. "Biodiversity is not regarded as an ecosystem service itself, but rather as a pre-requisite underpinning each of them. The precise link between the fact of diversity and the

capacity of an ecosystem to provide services is a complex one, and an area in which science is still developing [39]. The principle framework for expressing the "usefulness" of biodiversity is through the concept of ecosystem services. They illustrate the link between, on the one hand, the "interactions of species with each other and with the physical environment; and on the other, the well-being of people, whether in terms of wealth, nutrition or security" [39]. More diversity equates to greater redundancy in a system. By reinforcing bio-diversity of the single sector oil exploration market one creates opportunities for tourism, locale food, restaurant and cultural enriching zones, manufacturing, Ag based industries, and parks to gather in.

Park system greenway

The current expansion in oil towns resembles urban sprawl more than planned growth. By viewing a resource boomtown through the lens of an ecological matrix one can begin to conceptualize the balance needed to promote resiliency. "The borders between different ecosystems are often diffuse. In the case of the urban environment, it is both possible to define the city as one single ecosystem or to see the city as composed of several individual ecosystems, e.g. parks and lakes" [40]. Creating transition zones and greenspace will help to set pre-boom boundaries and allow municipalities to contract to a more sustainable level during possible bust cycles.

A park system can have positive effects on the psychological well-being of the person experiencing it. One example is a study on the response of persons put under stress in different environments [41]. "The study showed that when subjects of the experiment were exposed to natural environments the level of stress decreased rapidly, whereas during exposure to the urban environment the stress levels remained high or increased. The same author noted significant decreases in hospital recovery times and a patient's need for pain medication". By adding more

environmental systems to an urban area one creates a resilient physical setting conducive to handling shocks due to economic or natural events.

Resiliency

The very nature and self-descriptive qualities of a western North Dakotan resident is independent and resilient. "Local resiliency with regard to disasters means that a locale is able to withstand an extreme natural event without suffering devastating losses, damage, diminished productivity, or quality of life and without a large amount of assistance from outside the community"[42]. Designing with this quality in mind helps a region protect itself from stressors and disturbances which cannot be predicted. Using biological examples one can create a resilient system. The proper vision, analysis, multi-disciplined, master planned, constructed and monitored design can yield stakeholders their desired results.

In the book "Principles for Building Resilience: Sustaining Ecosystem Services in Social-Ecological Systems" [43} several methods have been identified that would work to produce a resilient network of social ecological systems as well as diverse ecosystems. These adaptive management strategies should be studied further. They include: Maintaining diversity and redundancy, Managing connectivity, Manage and slow variables and feedbacks, Foster complex adaptive system thinking, Encourage learning, Broaden participation, and Promote polycentric governance. This approach would benefit the changing region of western North Dakota.

These adaptive management strategies can be used to gain insight and develop solutions for issues facing the oil patch. See Figure 1

Matrix based on Principals of Resilience Thinking with 4 elements of sustainable solutions

	Social	Biological	Design	Recruitment
Maintain Diversity and Redundancy	Provide positive environment for new comers as well as existing residents. Prepare for growth and develop many adequate social systems.	Insure a healthy eco-system and balance nature with population growth through protection.	Design new communities with a boom bust cycle in mind. Provide green infrastructures and elements of the community that can be easily restored.	Provide training for multiple industries and recruit workers with a diverse skill set.
Manage Connectivity	Provide support groups for new comers trans-portation to larger cit-ies. Make airport travel accessible for family members.	Use a patch corridor matrix model for wild life habitat. Provide wildlife corridors to prevent habitat fragmentation.	Through sustainable parks and green infra-structure deign green ways for natural and human connections	Have agencies, employers and govern-ment entities provide provide support for the people they recruit to the region.
Manage Slow Variables and Feedbacks	Collaborate with so-cial agencies to provide support for new comers. Monitor crime and other trends effecting social well being.	Manage invasive species and ensure healthy ecosystem. Monitor negative effects from oil production.	Design systems that mitigate human impact and promote sustainable natural systems.	Monitor recruitment strategies, housing costs and living condi-tions. Gauge how these variables are effecting the ability for employers to field a work force.
Foster Complex Adaptive Systems Thinking	Work with an everchang-ing social environment. Be flexible and adapt to the social needs of newcomers, existing community members and employers.	Work with various agencies to mitigate a resource boom towns effects on the natural environment.	Design for growth and adapt to ebs and flow of boom and bust economies.	Recruit a diverse work force. Adapt to the boom and bust cycles of energy development.

Figure 1. Resilience Thinking Matrix

Matrix based on Principals of Resilience Thinking with 4 elements of sustainable solutions

	Social	Biological	Design	Recruitment
Encourage Learning	Create classes and educational tools based on surveys highlighting social needs.	Provide outreach and multi juristictional communication to educate stake holders, community members and employers about the natural resources of the area.	Educate members of the community about their natural systems, green infrastructure and the importance of sustainability.	Develop a curriculum geared towards the oil and gas industry and its sustainable use.
Broaden Participation	Include social agencies, community members, newcomers and stake-holders.	Include multi juristictional agencies, community members, newcomers and stakeholders.	Include multi juristictional agencies, community members, newcomers and stakeholders.	Include employers, industry and governmental in the recruitment process.
Promote polycentric goverment systems	Foster collaboration amongst governing and social agencies, community members, newcomers and stakeholders.	Act swiftly when environmental issues are discovered.	Design with the goal of stainability in mind.	Market, promote, and insentivise during the recrutment process

Figure 1. Resilience Thinking Matrix (continued)

Resource boom towns degrade the social systems; whether it be a newcomer, not from the area, or an old-timer, someone living in the area before the growth. They will both be under stress during the chaotic construction phase. The solution is to offer better opportunities for future social networking.

Design is important for the planning of multi-use community areas. The challenge that developers are often faced with when diversifying, is that resource based economies are often cyclical. Locations for residents to live eat work and socialize must be designed by using the

biological features which cause so much ecological functioning. With resiliency in mind, the

proper design is needed to prepare for stressors and shocks to the system.

DESIGN

A resource boomtown can be an opportunity for a community to take steps towards social, economic, and cultural balance. By understanding the social implications of rapid population growth and the ecological examination of bio-diversity, resiliency, and landscape connectivity the proper community goals can be achieved. Quality of life amongst stakeholders can be maximized by educating members as to the benefits of green infrastructure, habitat and communal connections, and natural parks. These elements should be used to improve the quality of life and showcase a community for possible long term recruits to an area.

Quality of Life

The proper design and planning can benefit a growing urban area. Green infrastructure and a well-designed park system can improve environmental quality and the lives of its human occupants. Humans have spent many thousands of years adapting to natural environments, yet have only inhabited urban ones for relatively few generations [44] [45] [46] [47]. Various forms of contact with nature, for instance, are known to produce restorative benefits [48]. To recruit and retain citizens to rural boomtowns it is important to provide communities that people would want to live. Sustainability is fundamentally concerned with the long-term maximization, balance, and maintenance of social, financial, and natural capital [49]. The challenge in obtaining the goal of sustainability is that it is subjective in nature. Being able to achieve and maintain a balance between these forces requires social stakeholders from Government entities, citizen groups, investors, landscape architects as well as others. The land use of an urban area should be planned with continued and long term sustainability in mind.

The natural systems that provide respite from daily stressors can be enhanced by connected park systems and well placed vegetation. Vegetation is essential to achieving the quality of life that creates a great city and that makes it possible to live a reasonable life within an urban environment [50]. According to Swedish economist Nils Lundgren, a good urban environment is an important argument for regions when trying to attract a highly qualified workforce. By creating a visually pleasing character and natural systems that enhance daily life, one can market there town to a productive and engaged work force as well as forward thinking businesses.

Financial

A major goal in our region is recruitment of a work force which will not only service an industry cyclical in nature but remain in local communities throughout the ebb and flow of varying economic cycles. Merrifield asserted that the first immigrants to an energy development area are basic sector employees. In addition to the influx of resource pioneers, high wage rates paid by the energy project draw many local residents away from their non-basic, service jobs. In order to design a region that can sustain a long term boom and bust cycle economic resiliency must be assured. Financial resiliency can be achieved by developing a more diverse economy. Economic-diversity can create resiliency by fulfilling different roles during different stressors and shocks to the system. By "weathering the storm" a community can use a strong socially networked group to continue to life and thrive in their town.

Social

If we are to understand what qualities of the environment are important to peoples quality of life, than we need to acknowledge the diversity that exists in people's capabilities, experiences, desires, and needs. Abstract experiential qualities such as perceptions of 'safety'

and 'attractiveness' have been identified as important factors in stated preferences for parks and green spaces [51]. By meeting the cultural need of a communities desire to have outdoor experiences we can begin to provide a stable environment to meet social needs of individuals thus improving the quality of life.

Environmental

The Natural capital that is being extracted from the ground has negative consequences for site sustainability "The Study of the Potential Impacts of Hydraulic Fracturing on Drinking Water Resources: Progress Report. EPA 2012" shows that produced water for fracking Bakken oil has up to 300 undisclosed chemicals. The man camps all create waste water and degrade the environment with poor location and materials designs. Oil may generate huge profits but it is nature that loses out. Proper design could use existing wetlands for waste filtration and plans could be adopted and enforced to assure well site cleanup. Working regionally on land conservation, master plan and zoning, conservation subdivisions, farm and rangeland BMP's, and wetlands or stream corridors and floodplain ordinances can mitigate the negative effects of oil production and population expansion. When too much human interaction is affecting natural and normal ecological function than greater habitat should be created tipping the scales back to the natural forces. Parks are great for this ecological matrix to take place in.

Natural Parks

Some scholars argue that park planning must strive to balance all the dimensions of sustainability, while others claim that this aim is not only unattainable, but unnecessary. Campbell [52] asserts there are always tradeoffs between the social, economic, and environmental dimensions of sustainability in planning; therefore it is impossible to give equal balance to all dimensions in every situation. In order for emerging cities to meet their many needs the parks

should be developed as a system. This system should be approached as a series of connections that meet the growing demands of its citizens and natural world. Some parks could be designed as recreational complexes while others could perform needed services such as waste water filtration. A park system successful at achieving the goals of reaching a sustainable balance could be a sense of pride and identifying element of a population center. To gain the much needed, broad-based public support for ecosystem preservation as well as more sustainable consumer demands, the places where people live and work need to be designed so as to offer opportunities for meaningful interactions with the natural world [53]. Once this is achieved the system could be used as a recruitment factor to potential inhabitants. See Figure 2
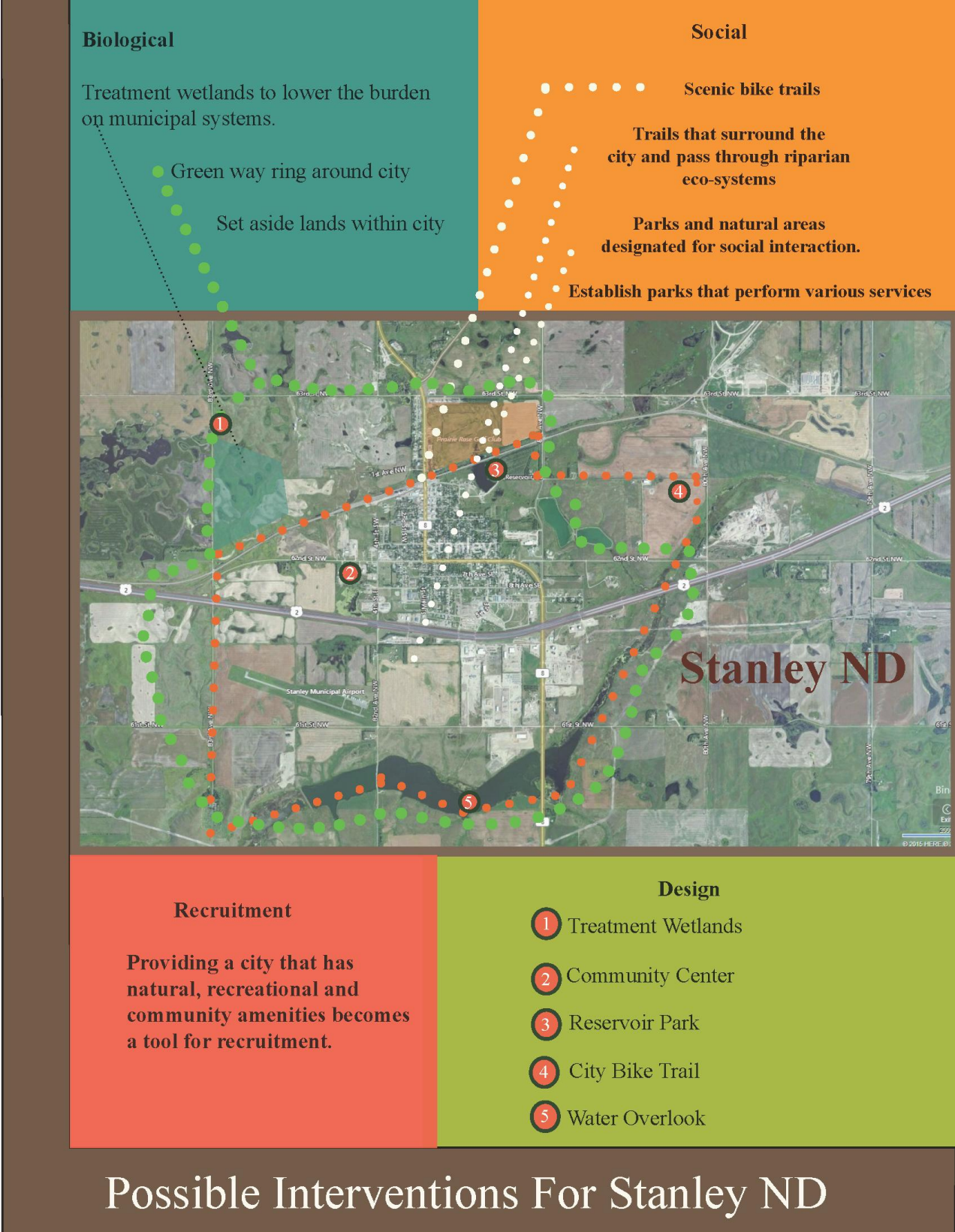
Biological

Treatment wetlands to lower the burden on municipal systems.

- Green way ring around city

- Set aside lands within city

Social

Scenic bike trails

Trails that surround the city and pass through riparian eco-systems

Parks and natural areas designated for social interaction.

Establish parks that perform various services

Stanley ND

Recruitment

Providing a city that has natural, recreational and community amenities becomes a tool for recruitment.

Design

1. Treatment Wetlands
2. Community Center
3. Reservoir Park
4. City Bike Trail
5. Water Overlook

Possible Interventions For Stanley ND

Figure 2. Interventions

Green Infrastructure

Green infrastructure can be designed into future development of communities experiencing rapid growth. Green infrastructures is defined as an interconnected network of green space that conserves natural ecosystem values and functions and provides associated benefits to human population [54]. Green infrastructure is a network composed of natural; lands, working landscapes, open spaces and the built environment that conserve ecosystems values and functions and provide associated benefits to human populations [55]. Green infrastructure can be viewed as an ephemeral solution to developments that may or may not survive a bust cycle. Ultimately, green infrastructure systems can ensure that the built environment does not just mitigate the impacts of development, but "regenerates" and improves the benefits and services provided by an underdeveloped landscape [56]. The development of a more ecologically sensitive community can become an identifying factor and sense of pride unifying both new comers and original residents. This type of infrastructure may empower communities to create something better than the sum of their parts. Educating stakeholders as to the value of environmental design will allow them to become proponents of your mission.

Teach it

Not all developers, government officials and criticizes are enthusiastic about the idea of designing a sustainable region. Developers and government officials alike are cautious about initial costs and are not always devoted to long term outcomes. Direct education is critical since many property owners will become stewards of the green infrastructure system. This expertise has to be delivered locally as systems are sensitive to local conditions. Showing how new technologies apply to local conditions using demonstration projects and educational programs is vital [57]. By educating a community as to the importance of their long term sustainability goals

members become stakeholders. Creating stake holders is one of the essential components to creating economic resiliency. Another equally important component is tying the communities into the resources and supporting industries throughout the region.

Included is a figure which demonstrates how various stakeholders can collaborate with one another to further educate and encourage learning about the issues at hand. See Figure 3
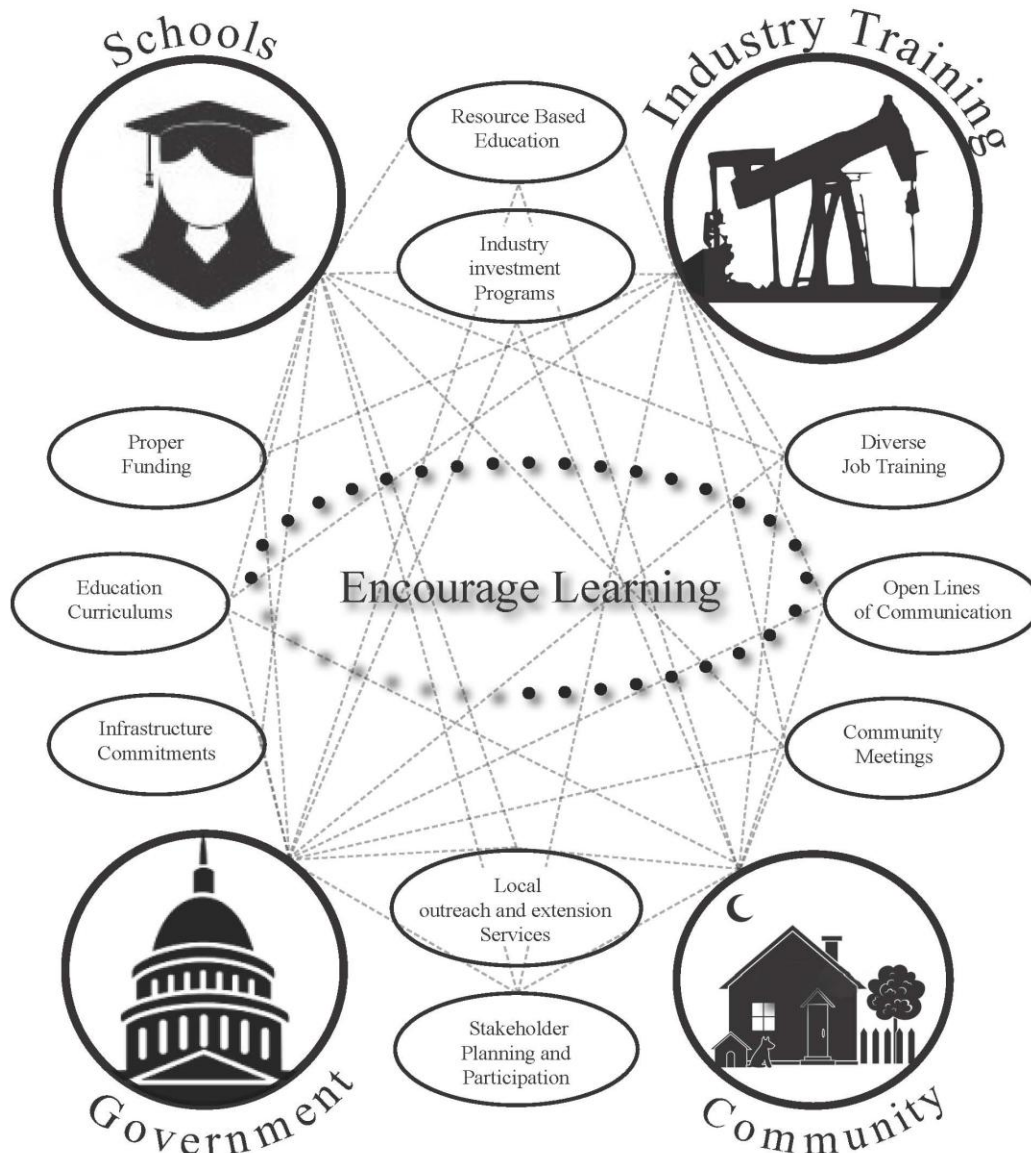

Figure 3. Stakeholder Participation

Connections

      Landscapes are composed of elements which are the spatial components that make up the landscape. A convenient and popular model for conceptualizing and representing the elements in a categorical map pattern is known as the patch-corridor-matrix model [58]. Under this model, three major landscape elements are typically recognized, and the extent and configuration of these elements defines the pattern of the landscape. Forman's model allows us to create areas for commerce, living, recreation, and circulation. Corridors are distinguished from patches by their linear nature and can be defined on the basis of either structure or function or both. Developing local and regional corridors would enhance resource boomtowns. The connections to markets and population centers would serve the communities by tethering them to larger social and commercial networks. If a corridor is specified, it is incumbent upon the investigator or manager to define the structure and implied function relative to the phenomena (e.g., species) under consideration[58]. The nature of the connections can be used for biological transition amongst biomes or humans moving about.

      The cold winters and vast rural expanses on the prairie make settling in western North Dakota a challenge. With isolation being a real social issue for new comers and their families it would be wise to provide connections to several networks. Connections locally, regionally and nationally would provide settlers of this area the opportunity to keep social ties and feel a stronger connection to the people and nature around them.   Forsyth and Musacchio [59] develop detailed park design guidelines. Their guidelines emphasize the importance of connectivity, diversity, and access for both human and non-human life. The same guidelines could be applied to city and regional planning. The importance of design cannot be understated. A regions ability

to retain and recruit the work force to continue and maintain economic permanence will be an

effort rooted in design and proper marketing of that vision.

RECRUITMENT

The benefits of a well-designed community can provide economic benefits through the ecosystem services provided by green infrastructure. The cultural services enhanced by well programmed design can draw potential recruits to rural areas in need of labor. Jacquet [2] explained the 4 stages of a boom town would progressively be: Enthusiasm (thoughts of development, economic gain, and increased tax revenue), Uncertainty (contractors arrive and negative impacts come to fruition), Near Panic (Services decline drastically and crime rates increase-anger and resentment), and Adaptation (acceptance of fate and hopefully welcoming of new comers). If resource boomtowns are to thrive once past the construction and development phase, let alone a bust, than a diverse and capable work force needs to be realized.

Psychology of a pioneer

New comers are in search of the American dream. Many aspire to work hard and begin a life of possibilities. For some their first chance to provide for a new family. For many the reason they are drawn to the Bakken is economic prosperity. The work is physically demanding and conditions in a boomtown are often challenging. The reason many people up root and resettle is for the possibility of upward social mobility. Many countries have witnessed a boom in the establishment of single-industry resource (e.g., Shale oil) towns in geographically remote areas [60]. To sustain existing booms for the near, intermediate and long term would be to promote a willingness to sustain initial challenges of the early boomtown syndrome and establish a balanced socially successful society.

For sustained commitment to a new area of settlement a newcomer must feel that they can begin an upward trajectory towards a better way of life. Researchers have codified the various motives for individuals migrating to isolated settlements. These include money (e.g., the

opportunity for better pay and to save); employment (e.g., increased job opportunities, ability to learn a new trade); standard of living (e.g., ability to improve quality of life); lifestyle (e.g., better environment to rear children); climate (e.g., seeking more conducive weather); and social ties (e.g., move to be with relatives or close friends) [61] [60]. Work in oil boom towns can lead to acceleration of expected upwards social mobility. These characteristics suggest that there are economic, sociological, and psychological reasons for individuals moving to remote areas. In the present context the main motive tends to be economic [62]. This may be inconsistent with other motives such as lifestyle, climate, and social ties. Brealy and Newton's research on mining employees has also observed that remuneration and job opportunities were primary reasons for migration. With the possibility of financial gain being a strong factor in the motivation of an economic pioneer, it would be wise to encourage new comers , through marketing, to capitalize on the possibilities of participating in a new diverse system.

The developers of mineral rich areas are often the companies wishing to capitalize on the resources. The nature of mineral extraction on a large scale can be repetitive and monotonous. There is a large body of evidence to indicate that employees dislike their jobs when undertaking repetitive work such as in mining [63] [64] [65]. Economic developers and members of government entities working towards a common goal of sustainability can recruit people willing to both develop the resources and remain socially invested during times of pause and bust.

Develop a pipeline of social stakeholders

In order to attract members willing to assimilate into the newly developing culture, an area must be willing to welcome new comers into the social systems which comprise the realm. The opportunity must possess the possibility of promise to the newly arrived member of society. We focus on specific domains of life satisfaction such as satisfaction with the lifestyle, the

education, recreational, and medical facilities in the town [66].   If essential needs are met then one can begin to assimilate into the culture. Both job security and promotional opportunity are elements of an organization's internal labor market [68] [67].   Employers and municipalities can work with new comers to communicate the vision of continued progress within the boom town.

If newcomers are provided the access to influence the continued development of a boom town than they would feel more socially connected to the system. We expect this non-work investment to influence job satisfaction. This is affirmed by Iverson and Roy, [69] who in a study of blue-collar employees from a pulp and paper manufacturer, observed community participation to be positively associated with job satisfaction. Conversely, the non-work cost of family isolation (as experienced by family members and employees) is expected to decrease an employee's job satisfaction [60]. The lack of social contact with friends and relatives is compounded by the size and location, as well as the harshness of the physical environment. Western North Dakota is far from any large urban areas. New workers often travel to the region alone and commute to their home state to keep social ties. By engaging in local networks and relocating family members to the region life satisfaction would be easier to obtain.

**Sustainable development (economically environmental)**

If business is affording the economic pioneers a chance to experience the diverse economy it resides in, then the stage is set. The rural area is just a location for the recruit to begin their economic ascension. The remote nature of prosperous resource extraction areas makes sustaining cultural ties a challenge. It is important to understand what characterizes a remote community. Homes [70] outlined six features that differentiate remote and isolated communities from urban areas (i) difficult physical environment, (ii) high economic and social cost involved in the exploitation of natural resources;(iii) unattractive places in which to live(iv) expensive

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basic services; (v) total population is restricted to a level required for the operation of the resource activity and is typically unbalanced and highly mobile; and (vi) population often considered to be deprived because of its isolation. These six features serve to highlight the social and economic costs of relocating to and living in remote communities. These are characteristics of the types of isolated communities we are hoping to assist mid boom in navigating the cycle of economic resiliency and sustained growth. To combat the isolation experienced in a resource boomtown social involvement programs are encouraged.

Economic Biodiversity-Resiliency to natural/economic disturbance

Social involvement in community organizations such as clubs, churches, voluntary organizations, local Government, co-ops, boards, and sporting leagues give workers the chance to relive stress while becoming social stakeholders in their communities. Families and coworkers benefit from these non-work related activities. Broadening the economic as well as social prospects allows for greater opportunities for change and social satisfaction.

Complex adaptive systems thinking models would benefit the Social, Recruitment, Design, and Biological issues associated with resource boom towns. Several solutions are redundant amongst the 4 elements. See Figure 4
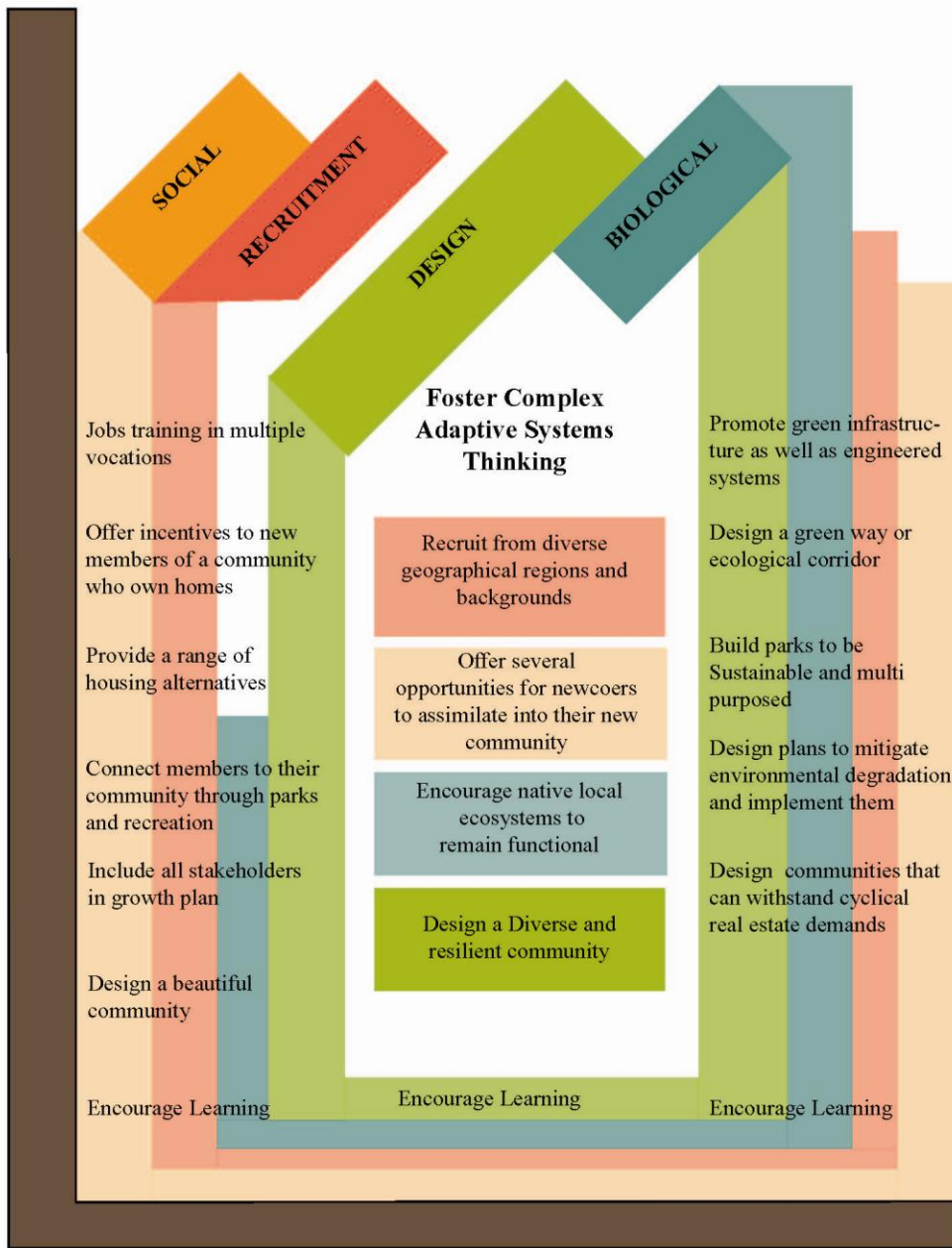
Figure 4. Complex Adaptive Thinking Spectrum

Life satisfaction

Cultural, social and environmental balance can be attractive attributes to market to potential recruits. Recent research suggests that employees with positive dispositions may perceive the rigors of living in a remote mining community as a challenge, while those employees with negative dispositions may perceive it as a threat [71]. This finding can be used to determine the type of stakeholders that have the greatest chance to become full time contributors to a resilient society. Employees displaying positive affectivity tend to experience a sense of wellbeing, self-efficacy, and positive affective states, whereas employees displaying negative affectivity (akin to neuroticism) tend to be subjectively distressed, un-pleasurably engaged, and experience negative affective states [72] [73]. Good work relations and community support allow members of a new boomtown to assimilate and work through challenges that occur during disturbance.

Workers like change and the opportunity to provide several different functions independently. Cross training and broad based skills knowledge prove valuable during and economic shift of disturbance. Loscocco and Roschelle [74] note that "employees' emotional wellbeing suffers when they do not receive valued job rewards, such as substantive complexity, challenge, and autonomy". Well rewarded stakeholders within a diverse economic environment are likely to thrive.

CONCLUSION

Diverse as well as sector specific education will be needed to meet the labor demands of the Western North Dakotan Oil boom. Now that the demands and conditions are being realized the region has the ability to develop plans to manage growth and maintain sustainable communities. Resource boomtowns have both positive and negative impacts to an area of development. The negative impacts for existing members should attempt to be mitigated. One of the greatest indicators of how new members are going to survive the boom is how well they assimilate during the early stages of development. If proper consideration is made for new comers during the construction phase of a resource boomtown and continued through production then stakeholders could be introduced to the growing area, its social networks, and its economic base.

The biological lessons gleaned from natural sciences are important to aid in the prevention and mitigation of negative impacts occurring in boomtowns. The resources available to residents and newcomers are abundant. With proper management the state could continue to have a thriving economy as well as meet the areas social and ecological needs. The ecological footprint of an area can have larger implications for a globally connected environment and economy. With increased bio-diversity of cultural, economic, and natural systems an area is more resilient to disruptions and shocks to the system. This is of great importance to a "resource boomtown", due to the volatility of resource markets and their exposure to geopolitical influences.

Proper planning and carefully strategic design solutions can greatly enhance the quality of life for existing members as well as new comers to a growing urban area. Parks and community defining green space, work towards building connections of residents to social

networks and the natural world. These connections are important for stakeholders to keep ties within the community and to the friends and family left during the migration to a new area. If residents, visitors, and potential recruits are educated about the communities sustainable goals they too can share in the vision.

Recruitment of social as well as economic stakeholders is important to the long term sustainability of a resource boomtown. To understand the motives of a resource pioneer is to begin to understand how to draw them to an area. Developing a pipeline of socially involved long term members of a community to construct and maintain that locale should be done in the early stages of a boomtown. By marketing a quality of life advancement and an environmental experiential sustainable future, towns can recruit citizens to participate in new urban centers permanently.

Proper education can assure the new and current residents create goals and execute plans to achieve them. To meet the labor demands and societal challenges a curriculum tailored to specific regional issues should be developed. This curriculum should include both positive and negative impacts of resource development. Regional planning and post development sustainability would benefit stakeholders of resource boom towns. To meet the labor demands and societal challenges a curriculum tailored to specific regional issues should be developed. The ability for today's learners to be productive stakeholders lies within the educational system. The environment will need to be restored and maintained. The culture needs to be one of educated citizens which have information to decide what works best for their communities. The oil industry would benefit from energy based curriculums reaching into the local collages.

Recommendations and areas to proceed

With the desire to create a resilient system to withstand shocks to the environmental, social, and economic system an inventory of current activities in relation to the recent resource boom should be studied. The results of this research could be compared to prior boom/bust cycles and the current booms pre construction conditions. By understanding the ebb and flow of this cycle stakeholders can take steps to diversify their economy and smooth out the peaks and valleys.

Several facets of the culture should be considered with regards to recruitment of a viable workforce. For example: does the development of green infrastructure and parkways help people to connect to the community and its natural environment? Do these nature connections aid in a new comers ability to develop social connections and a sense of belonging? Are other regions strengthening their geographical connections in hopes of diversifying their economies?

A study should be instituted to investigate the proposition that a sustainable approach will validate the upfront investment in western North Dakota Resource Boomtowns. Investments in education (sector related as well as broad vocational), green infrastructure, social systems and regional connections, and environmental mitigation would aid and promote attempts to create a resilient region. It is my belief that through thoughtful planning and design the positive effects of resource development can be realized.

This issue needs further study from a multidisciplinary approach.

Areas that would benefit from future study include education, infrastructure, labor and jobs. In an NDSU study Population, Education, Housing, crime, infrastructure, labor and employment, economy were listed as the main aspects to be impacted during a boomtowns

growth phase [75].   I find education, infrastructure, and employment to be the factors of significant relevance and worthy of future research.

Education- If the state of North Dakota can develop an education curriculum which teaches sustainable uses of its natural resources than it will be more equipped to handle the future challenges associated with common boom and bust cycles of resource development. Both diversity and redundancy should be considered from the earliest stages through higher education. Sector specific teaching and broad ranged curriculums would benefit the state for years to come.

Infrastructure- The development and implementation of green infrastructure can serve the communities within the oil patch by meeting their infrastructure need and obtaining ecosystem services associated with clean air, clean water, and cultural aesthetic beauty. Green infrastructure can be a multifunctional element of the landscape which if abandoned can go back to its natural state with little cost or effort. Some examples of green infrastructure which would Resource Boomtowns could utilize are rain gardens, bio-retention and treatment wetlands, vegetated/dry swales, stream buffer restoration, and grassy filter strips.

Labor and jobs-The exploration of oil and gas has increased demand for construction jobs and supporting jobs in western North Dakota. While the availability of jobs are present, the lack of affordable housing discourages potential applicants from relocating to the area. Developing a better understanding of the relationship between housing and its impacts of the labor force would benefit both employers and employees.

Some possible steps and direction that may come out of further research are:

1. Set plans of growth that can be ramped up if need be and develop a state wide curriculum to become properly educated about oil extraction and community involvement.

2. Develop city centers as an area easy to meet others and find social support groups. Local services, local clubs, and local support teams working in the city center.

3. Purchase lands surrounding the current cities. Provide infrastructure to the border and make the rest into a city border or Emerald Necklace.

4. Adopt ecofriendly storm water management practices, and use as much rain as possible.

5. Provide several uses within the Emerald Circle surrounding the city. Cultural and environmental services will be allowed to flourish in the new green belt.

6. This would be a great time to cross train for new industries that would love to get a foothold in the area. Welcome all new enterprises to the area.

7. Design an awards wining parks system that caters to a specific programs that benefit from vast green space and ecological connections.

8. Recruit newcomers and their families to the area with the promise of assimilation into a safe community.

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